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Milpa agroforestry system. Photo: José Espinoza-Pérez

The milpa agroecosystem: a case study in Puebla, Mexico

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"The management of multiple crops has allowed the milpa to coexist with native ecosystems and has supported the conservation of natural resources."

Introduction

One of the emblematic agroecosystems practised since ancient times in the biocultural regions of Mexico is the milpa system (Pérez-García and del Castillo 2016, 2017). It is composed of multiple native crops of importance for food security and agriculture. One of its characteristics is the association of maize with leguminous plants (beans), cucurbits (pumpkins), chillies and tomatoes, edible greens (*quelites*) and various perennial woody species.

Crop and/or land rotation is a crucial component in the sustainability of this agroecosystem. The management of multiple crops has allowed the milpa to coexist with native ecosystems and has supported the conservation of natural resources. The milpa is considered a sustainable production system because it supports high productivity through the efficient use of natural resources.

Attempts to modernize traditional agriculture by government agri-food and environmental policies and programmes have threatened the milpa system (Pérez-García and del Castillo 2016, 2017). However, the adoption of modern agricultural practices by farmers and Indigenous peoples has not been widespread. Basically, they have adopted some components of commercial agriculture, such as continuous production on the same land, use of synthetic fertilizers and agrochemicals, and maize monocropping. Despite these changes in the milpa system, local populations continue to use native maize seeds.

Due to the country's diverse and contrasting biocultural regions, the persistence of the milpa system in the face of maize monocropping requires study, particularly in terms of the socio-ecological context. This is necessary in order to identify the socio-environmental factors that support or hinder the permanence of the milpa.

This article discusses the agroforestry milpa and maize fields of the Totonacapan region in the northeastern highlands of Puebla, Mexico. Totonacapan farming families in the highlands cultivate one of two maize production systems: the milpa and the maize field, or *maizal*. The milpa is oriented to the production of food for self-consumption, and the latter is a system recently adopted in the region for commercial purposes. The following questions were posed: Why does the milpa system persist over the maize field in the same cultural and environmental space? What direct and intangible benefits do families obtain from both systems? To answer these questions, work was carried out with 32 farming families (16 milpa farmers and 16 maize field farmers) to document the direct benefits (food and income) and intangible benefits (food security and food sovereignty). In addition, the costs and benefits of the milpa and *maizal* systems were explored.

The role of useful plants in the milpa and in the maize field

The milpa

The milpa is sown once a year (December to June) and 69 useful species are cultivated in it (see photo a, next page). Among the basic food crops are maize, beans, tomatoes and chillies as well as complementary food sources such as *quelites* and fruit trees. Maize and beans are the most important crops in the milpa, given that they provide food security at the family level in the face of rising prices for maize and tortillas, due to the impact of climate change and food shortages caused by Covid-19. Maize is the preferred crop, being the main and most significant product for farming families. The growing of other crops and fruit trees in this system contributes to the family economy by diversifying the diet and occasionally generating monetary income through the sale of surplus products. The use and consumption of *quelites* also contribute to the diversification and provision of food for farming families. From maize, families are self-sufficient for an average of nine months of the year, while other crops sustain the family for a few months (Figure 1).

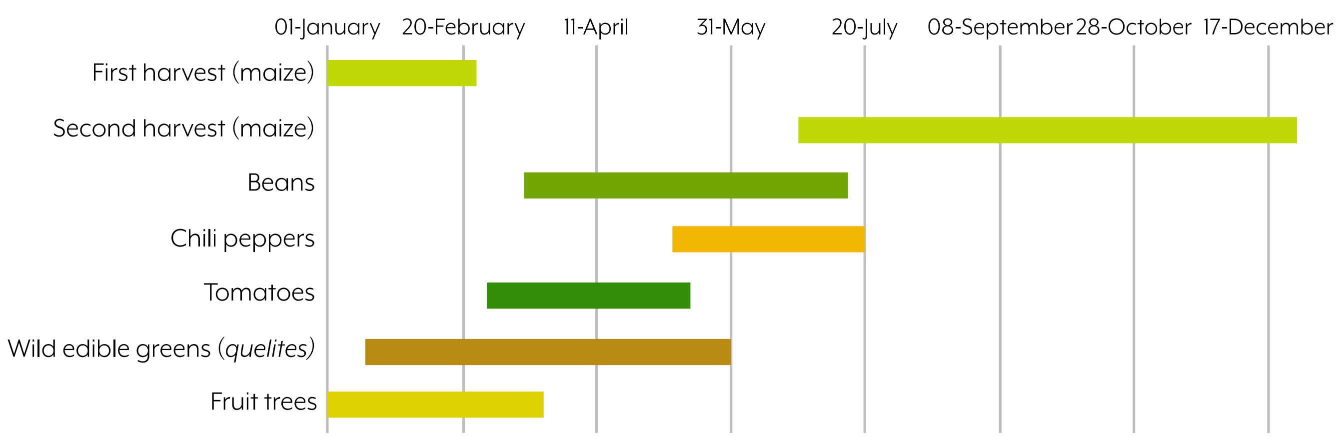

Figure 1. Self-consumption food produced in the milpa and period of consumption during the year

Of the shrub and trees in the milpa, seven species were identified as having a food use. The most important were gásparo (*Erythrina caribaea*) and *equizote* (*Yucca aloifolia*), which had the greatest presence in the plots and highest frequency of consumption in the families' diets (Espinoza-Pérez et al. 2023). In addition, shrub and tree species are used as firewood. *Inga* sp. is also considered useful for the control of weeds and for strengthening soil fertility (because it is a nitrogen fixer) and it contributes to lower doses of synthetic fertilizers being required in the milpa. Another species that contributes to this function is *higuerilla* (*Ricinus communis*), which is useful for weed control and, because it has a high density in the milpas, for fuel too (see photo b, below).

Farmers commented that material from the milpa, especially the leaves of the *higuerilla*, when incorporated into the soil, generates a natural mulch, favouring soil conservation and control of weeds. In addition, in the milpas, perennial woody species are often left standing or as live stumps due to their use as stakes/supports for beans (see photo c, below). Therefore, it is common to observe a high number of individuals of species that fulfil this function: *timbirillo* (*Acacia angustissima*), *mujut* (*Conostegia xalapensis*) and *capulín* (*Parathesis psychotrioides*). See Table 1. In addition, *timbirillo* is a nitrogen-fixing shrub, which forms islands of fertility, increases soil organic matter and prevents soil erosion (Reyes-Reyes et al. 2003), while the other two species are useful as food, and in hot maize-based beverages (*atole*) and wine production at the local level.

In other rural regions of Mexico, some non-woody species are used to delimit milpa plots, such as *nopal* (*Opuntia* spp.) and *maguey* (*Agave* spp.). These species serve multiple purposes, including providing edible and medicinal products. In addition, it is locally recognized that the woody cover of the milpa favours soil fertilization through the leaves, branches and trunks that are incorporated for decomposition. On sloping land with poor soil retention, fruit trees and woody perennials are used to stabilize banks or serve as retaining walls or windbreaks, and as sources of organic matter, firewood and charcoal. The fruit species commonly found in borders and plot boundaries are *capulín* (*Prunus capuli*), *durazno* (*Prunus persica*), *tejocote* (*Crataegus mexicana*), *manzana criolla* (*Malus domestica*) and *ciruelo* (*Prunus*

Milpa production method, including a) sowing; b) milpa agroforestry system; c) shrubs as bean supports; d) storage of maize cobs; e) tortilla production. Photos: José Espinoza-Pérez

domestica). Timber species are also found: *encino* (*Quercus* spp.), *pino* or *ocote* (*Pinus* spp.), *sabino* (*Juniperus deppeana*) and *tepozán* (*Buddleja americana*); see Pérez-Sánchez 2012; Moreno-Calles et al. 2013.

The maize field (maizal)

In the northeastern highlands of Puebla, the maize system is being used for commercial purposes. In addition to maize, peasant families incorporate other crops for commercial purposes: *pipian*, tomatoes, tree species such as *pimienta* (*Pimenta dioica*), and commercially valuable timber trees: *cedro* (*Cedrela odorata*) and *caoba* (*Swietenia macrophylla*). In addition to these commercial species are *chaca* (*Bursera simaruba*) and *cocuite* (*Gliricidia sepium*) trees, used to delimit boundaries and as living fences and sources of firewood. The difference in crops and the density of shrub and tree species between the milpa and the maize field is notable (Table 1). In the maize field, farmers grow an improved maize variety, *hojero* (*Zea mays*). The farmers' rationale for growing this variety is that it produces mature ears that are 25 to 30 centimetres long and soft-grained, with leaf cover up to eight centimetres above the cob. Such characteristics mean that the improved variety has been outperforming the native *tuxpeño* maize, but growers recognize that it has less resistance to storage pests than the native maize does (see photo d, previous page). As a result, the crop has to be sold within the first two months after harvest (Andrés-Meza et al. 2014).

Table 1. Density and function of shrub and tree species in milpas and maize fields

		Density / ha		
Scientific name	**Common name**	**Milpa**	**Maize field**	**Function**
Yucca aloifolia L.	*Equizote*	4	0	Boundary and food
Pimenta dioica (L.) Merr.	*Pimienta*	2	4	Cash crop
Cedrela odorata L.	*Cedro*	2	3	Cash crop
Swietenia macrophylla King	*Carboncillo*	2	0	Cash crop
Citrus sinensis (L.) Osbeck.	*Naranja*	2	4	Food
Ricinus communis L.	*Higuerilla*	23	0	Helps control the growth of weeds
Heliocarpus appendiculatus Turcz.	*Jonote*	2	0	Firewood
Acacia angustissima (Mill.) Britton & Rose	*Timbirillo*	31	0	Stakes for beans
Conostegia xalapensis (Bonpl.) D. Don ex DC.	*Capulin*	12	0	Stakes for beans and food
Eugenia capuli (Schlecht. et Cham.) Berg	*Capulincillo*	1	0	Tool
Diospyros nigra (J. F. Gmel.) Perr.	*Zapote negro*	2	0	Food
Inga vera Willd.	*Chalahuite*	7	0	Shade, weed control and soil fertility
Mangifera indica L.	Mango	1	2	Food
Parathesis psychotrioides L.	*Capulin*	7	0	Stakes for beans and food
Pouteria sapota (Jacq.) H. E. Moore & Stearn	*Zapote mamey*	1	0	Food
Prunus persica (L.) Batsch	*Durazno*	4	2	Food
Citrus x limon (L.) Burm. F.	*Limón*	0	4	Food
Bursera simaruba (L.) Sarg.	*Chaca*	4	12	Fence
Gliricidia sepium (Jacq.) Kunth ex Walp.	*Cocuite*	0	14	Fence
Erythrina caribaea Krukoff & Barneby	*Gásparo*	3	0	Boundary and food

Production costs and benefits of milpa and maize fields

The milpa system

In the milpa, clearing and weed management are carried out three times during the growing season. During the same period, the family gathers firewood from fallen branches and trunks. The main agricultural tool used for clearing is the *azadón*, an instrument consisting of a wide, thick blade, sometimes curved, inserted into a wooden handle made from the tree known locally as *capulincillo* (*Eugenia capuli*), which is grown in the milpa. Weeding is done with the *azadón*, or occasionally with a machete, and there is no use of herbicides. No incidence of insect pests was reported in the milpas. However, most of the farmers agreed on one problem: the damage to maize and other plants by birds and small mammals (rats, gophers, squirrels, opossums, white-nosed coati). Farmers nevertheless recognize that these animals are part of the agroecosystem and that although they cause problems, they do not have serious impacts on production and it is possible to manage these effects.

In one growing season, to cultivate 1 ha of milpa, families invest an average of MXN 43,750 (Mexican pesos; USD 2,581), which includes clearing the cultivation area, sowing, fertilizing and transporting the harvest. However, because of the fertilizer support they receive from the state government and the prevalence of community labour (*mano vuelta*) among the farmers, they save on average MXN 16,500/USD 974 per hectare. From the sale of maize and beans, they earn MXN 13,500/USD 797, which implies a loss of MXN 3,000/USD 177. This, however, does not consider that the consumption of their own maize (tortillas) by the families during nine months involves a saving of MXN 21,900/USD 1,293; otherwise, this would be an expense.

Herbicide application in the maize fields.
Photo: Francisco Ramos López

Maize fields

Maize fields are cultivated twice a year. For one season and 1 ha, farmers invest an average of MXN 15,150/USD 894, which involves digging an *acahual* (fallow), planting maize, buying and applying herbicides (see photo above) for weed control as well as insecticides and foliar fertilizers, paying wages and transporting the harvest. From the sale of maize cobs for tamales, grain, *pipian*, tomatoes and peppers, the families generate an average total income per season of MXN 25,300/USD 1,493. This means a profit of MXN 10,150/USD 599. However, these families spend an average of MXN 6,500–7,250/USD 384–428 for the purchase of tortillas in six months. See Table 2.

Table 2. Costs and income/savings (+) per hectare (USD), milpa and maize fields

Cost	Milpa	Maize field
Clearing, planting, transport, etc.	2,581	894
Fertilizer support	* + 974	—
Average income	+ 797	+ 1,493
Purchase of tortillas	* + 1,293	384–428
Net income per ha	**+ 483**	**+ 171–215**

* The cost of fertilizer is saved as the government provides it for free.
* As noted above, milpa farmers save this amount because they can consume their own maize/tortillas for nine months of the year.


Packets of dry bracts of maize which are marketed in Mexico City and the capital of Puebla. Dry bracts are used to wrap tamales (a typical Mexican dish). Photos: Francisco Ramos-López

The families who cultivate maize fields recognize that it is difficult to return to the milpa system, largely because of the degradation of the soil; restoring it means leaving the cultivated area in *acahual* for at least seven years. Similarly, they are no longer willing to use the *azadón* as a substitute for herbicides to eliminate weeds in the cultivated areas.

Conclusions

The milpa agroforestry system persists over maize fields for several socio-environmental reasons. The milpa provides basic and traditional foods (maize, beans, chillies, tomatoes), generates savings and economic income, and also produces environmental benefits. The milpa produces native maize, which is locally preferred for reasons of adaptation and culinary traditions. In addition, the milpa allows people to diversify their diet and generate monetary income from the sale of surpluses, mainly beans and sporadically grain. Perennial woody plants fulfil several functions such as soil conservation and the production of firewood and timber. And by employing collective community labour, known as *mano vuelta*, production costs are relatively low.

In contrast, families who adopt the maize system think that cultivating milpa generates economic losses and requires a lot of effort. However, floristic simplification in the transition from milpa to maize fields directly affects the presence of locally used staple crops and beneficial shrubs and trees for soil fertility and pest control. The elimination of the bean crop in the maize field leads to the low presence of shrubs used as stakes/supports. In addition, the farming families who cultivate the maize fields recognize that they have lost the capacity to produce their own food, specifically maize, which is used to make tortillas and has a very high cultural value in Mexico.

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